ENVIRONMENTAL MANAGEMENT SCIENCE PROGRAM (EMSP) SYMPOSIUM
(Cosponsored with the Division of Analytical Chemistry)
(Cosponsored with the Division of Geochemistry)
(Cosponsored with the Committee on Environmental Improvement)
Environmental Sensing and Monitoring:
Effects of Radiation Exposure on Humans and Biota

DIVISION OF ENVIRONMENTAL CHEMISTRY
225th American Chemical Society Meeting
New Orleans, LA
Thursday, March 27, 2003

Organizer: **T. Zachry**

Presiding: **E. Berkey**

Time	**Paper**
1:30 p.m.	Introductory Remarks.
1:40 p.m.	**Environmental monitoring using micromechanical sensors.** T. Thundat
2:05 p.m.	**Spectroelectrochemical sensor for technetium: Preconcentration and quantification of technetium in polymer modified electrodes.** D.J. Monk, M.L. Stegemiller, S. Conklin, J.R. Paddock, W.R. Heineman, C.J. Seliskar, T.H. Ridgway, S.A. Bryan and T.L. Hubler
2:30 p.m.	**Sensors and automated analyzers for radionuclides.** J.W. Grate and O.B. Egorov
2:55 p.m.	Intermission.
3:20 p.m.	**Airborne particle size distribution measurements at USDOE Fernald.** N.H. Harley, P. Chittaporn, R. Medora and R. Merrill
3:45 p.m.	**Visualization of DNA double-strand break repair at the single-molecule level.** W. Dynan, S. Li, Y. Takeda and S. Wragg
4:10 p.m.	**Environmental radiation effects: A need to question old paradigms and to enhance collaboration among radiation biologists and radiation ecologists.** T.G. Hinton, J. Bedford, F.W. Whicker and B. Ulsh
4:55 p.m.	Concluding Remarks.

ABSTRACTS

Environmental monitoring using micromechanical sensors. Thomas Thundat; Life Sciences Division, Oak Ridge National Laboratory, ORNL, MS-6123, Oak Ridge, TN 37831, Fax: 865-574-6210, ugt@ornl.gov.

There is presently an urgent need for rugged, low cost sensing systems for real-time, *in situ* chemical sensors for characterization and monitoring of ground water, contaminated soil and process streams. Recent advances in designing and fabricating microcantilever beams capable of detecting extremely small forces, mechanical stress and mass additions offer the promising prospect of environmental sensing with unprecedented sensitivity and dynamic range. The resonance frequency of a cantilever beam varies sensitively as a function of molecular adsorption. In addition, when the adsorption is confined to one side of the cantilever, the cantilever undergoes deflection due to adsorption-induced variation in surface free energy. Chemical selectivity can be achieved by coating the cantilevers with selective molecules. We have detected a number of ions such as Cs, Cr, Cu, Hg and methyl Hg in ground water with very high sensitivity. Recent results from nanocantilever sensor arrays will be presented.

Spectroelectrochemical sensor for technetium: Preconcentration and quantification of technetium in polymer modified electrodes. David J. Monk[1], Michael L. Stegemiller[1], Sean Conklin[1], Jean R. Paddock[1], William R. Heineman[1], Carl J. Seliskar[1], Thomas H. Ridgway[1], Samuel A. Bryan[2] and Timothy L. Hubler[3]; [1]Department of Chemistry, University of Cincinnati, P.O. Box 210172, Cincinnati, OH 45221-0172; [2]Radiochemical Processing Laboratory, Pacific Northwest National Laboratory; [3]Environmental Molecular Sciences Laboratory, Pacific Northwest National Laboratory.

A remote spectroelectrochemical sensor and instrumentation package is being developed for the detection of aqueous pertechnetate in the vadose zone. This sensor can be employed to monitor the integrity of low-level and high-level nuclear waste containment at U.S. DOE sites. A brief review of previous advancements and current development of this sensor is described. Initial spectroelectrochemical studies of pertechnetate using unmodified and polymer modified optically transparent electrodes have shown that the polymer modified electrode will readily preconcentrate pertechnetate. The electrodeposition of technetium oxide in these films is shown to be a method for the quantitative spectroelectrochemical determination of technetium and has been verified using radiochemistry dose measurements and scanning electron microscopy. The irreversible electrochemical nature of pertechnetate in polymer modified electrodes demonstrates the need to identify a ligand capable of complexing with technetium, to allow reversible detection and to provide additional chemical selectivity.

Sensors and automated analyzers for radionuclides. Jay W. Grate and Oleg B. Egorov; Pacific Northwest National Laboratory, P.O. Box 999, Richland, WA 99352.

The production of nuclear weapons materials has generated large quantities of nuclear waste and significant environmental contamination. We have developed new, rapid, automated methods for determination of radionuclides using sequential injection methodologies to automate extraction chromatographic separations, with on-line flow-through scintillation counting for real time detection. This work has progressed in two main areas: radionuclide sensors for water monitoring and automated radiochemical analyzers for monitoring nuclear waste processing operations. Radionuclide sensors have been developed that collect and concentrate radionuclides in preconcentrating minicolumns with dual functionality: chemical selectivity for radionuclide capture and scintillation for signal output. These sensors can detect pertechnetate to below regulatory levels and have been engineered into a prototype for field testing. A fully automated process monitor has been developed for total technetium in nuclear waste streams. This instrument performs sample acidification, speciation adjustment, separation and detection in fifteen minutes or less.

Airborne particle size distribution measurements at USDOE Fernald. Naomi H. Harley[1], Passaporn Chittaporn[1], Riasp Medora[2] and Richard Merrill[2]; [1]Dept. of Environmental Medicine, New York University School of Medicine, 550 First Avenue, MSB C90, New York, NY 10016, Fax: 212-263-5287, naomi.harley@med.nyu.edu; [2]Radiation Control Section, Fluor Fernald.

There are no long term measurements of the particle size distribution and concentration of airborne radionuclides at any USDOE facility except Fernald. Yet the determinant of lung dose is the particle size, determining the airway and lower lung deposition. Beginning in 2000, continuous (6 to 8 weeks) measurements of the aerosol particle size distribution have been made with a miniature sampler developed under EMSP. Radon gas decays to a chain of four short lived solid radionuclides that attach immediately to the resident atmospheric aerosol. These in turn decay to long lived polonium 210. *Alpha* emitting polonium is a tracer for any atmospheric aerosol. Six samplers at Fernald and four at QC sites in New Jersey show a difference in both polonium concentration and size distribution with the winter measurements being higher/larger than summer by almost a factor of two at all locations. EMSP USDOE Contract DE FG07 97ER62522.

Visualization of DNA double-strand break repair at the single-molecule level. William Dynan, Shuyi Li, Yoshihiko Takeda and Stephanie Wragg; Institute of Molecular Medicine and Genetics, Medical College of Georgia, 1120 15th Street, Augusta, GA 30912, Fax: 706-721-8752, wdynan@mail.mcg.edu.

Exposure to low doses of ionizing radiation is universal. The signature injury from ionizing radiation exposure is induction of DNA double-strand breaks (DSBs). The first line of defense against DSBs is direct ligation of broken DNA ends via the

nonhomologous end-joining pathway. Because even a relatively high environmental exposure induces only a few DSBs per cell, our current understanding of the response to this exposure is limited by the ability to measure DSB repair events reliably *in situ* at a single-molecule level. To address this need, we have taken advantage of biological amplification, measuring relocalization of proteins and detection of protein phosphorylation as a surrogate for detection of broken ends themselves. We describe the use of specific antibodies to investigate the kinetics and mechanism of repair of very small numbers of DSBs in human cells by the nonhomologous end-joining pathway.

Environmental radiation effects: A need to question old paradigms and to enhance collaboration among radiation biologists and radiation ecologists.
Thomas G. Hinton[1], Joel Bedford[2], F. Ward Whicker[2] and Brant Ulsh[2]; [1]Savannah River Ecology Laboratory, University of Georgia, Drawer E, Aiken, SC 29802, Fax: 803-557-7324, thinton@srel.edu; [2]Radiological Health Sciences, Colorado State University.

A historical perspective is given of the current paradigm that does not explicitly protect the environment from radiation, but instead, relies on the concept that if dose limits are set to protect humans then the environment is automatically protected as well. We summarize recent international questioning of this paradigm and briefly present three different frameworks for protecting biota that are being considered by the U.S. DOE, the Canadian government and the International Commission on Radiological Protection. We emphasize that an enhanced collaboration is required between what has traditionally been separated disciplines of radiation biology and radiation ecology if we are going to properly address the current environmental radiation problems. We then summarize results generated from an EMSP grant that allowed us to develop a Low Dose Irradiation Facility that specifically addresses effects of low-level, chronic irradiation on multiple levels of biological organization.